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TECHNICAL RESEARCH REPORT 1123

Monitor Performance Task--
Status Report, 30 June 1962

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(An Activity of the Chief of Research and Development)

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USAPRO Technical Research Report 1123

MONITOR PERFORMANCE TASK--
STATUS REPORT, 30 JUNE 1962

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June 1962

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BRIEF

MONITOR PERFORMANCE TASK--
STATUS REPORT, 30 JUNE 1962

Requirement:

An expanding military technology is creating a group of jobs in which an important duty of the system operator is the prolonged observation of instrument panels and scopes for critical signal detection. A major objective of this task is the improvement of monitor performance on such jobs through the use of job engineering and personnel selection techniques.

Procedure:

Work in three subtasks constitutes the major approach to this task:

a. Study of Army Drivers Performing on the AASHO Road Test, now completed.

b. Experimental Laboratory Studies of Vigilance Behavior, in process.

c. Human Factors Studies of Critical Jobs in the Operational Setting, in process. Research problems have been defined and pilot studies in information monitoring have been completed.

Findings to Date:

1. The AASHO studies pointed up the need for additional and refined research on differential performance decrement, as well as the need for better selection instruments.

2. In connection with subtask b, it was found that of a total of 1528 duty positions examined, 102 have "vigilance" components; the majority under the cognizance of the combat arms.

Utilization of Findings:

The substantial number of jobs requiring vigilance, the wide distribution of these jobs across service elements, and the human factors problems areas cited by duty personnel confirmed the operational need for improvement in work methods and techniques. It also confirmed the utility of a broad program of vigilance research. Both the AASHO studies and the survey of Army jobs having a vigilance component have led to recognition of the need for a versatile laboratory simulator through which the relevant features of many important monitor jobs may be experimentally studied Specifications for the simulator have been established, and experimental designs for study of selected factors in relation to performance have been worked out.

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TASK OBJECTIVES

The Task was initiated as the Error-Free Performance Task in the Combat Systems Research Laboratory at the beginning of FY 1960 with the main objective of developing selection techniques to improve the dependability of human performance in jobs or critical importance but of simple content. Need for the Task derived from recognition that, in the newer man-machine systems, much of the earlier dependence on operator judgment was being engineered out of the jobs by use of automated equipment and highly routinized procedures. In jobs thus simplified, the most important aspect of operator performance is dependable, relatively "error-free" performance--the reliable performance of a simple action at the required moment. Thus, research on monitor performance was molded by the concept of the "dependable man" rather than by the concept of the skilled technician.

As research plans developed in response to exploratory studies and examination of Army needs for various kinds of monitor performance, the scope and direction of the Task also developed. While the objective of selecting personnel with better potential for monitor jobs was retained, there was heightened emphasis on utilization of monitors to the best advantage within a combat system. This objective was accompanied by a growing realization that specific problems of monitor utilization could be studied adequately only through experimental techniques applied under laboratory controls.

The "push-button" soldier remains a futuristic concept. However, there are combat jobs which require operators to monitor--more or less passively--instrument panels, radarscopes, communications nets, and various signal detection apparatus of Army weapons and surveillance systems. Dependable performance of these "reaction-to-signal" duties, sometimes over extended periods of time, is a well-defined requirement of a considerable number of Army jobs. The psychological requirement involved in the signal detection aspect of monitor jobs is termed "vigilance." Independent investigations have repeatedly demonstrated that human performance in such tasks tends to deteriorate. Because an increasingly higher proportion of Army manpower can be expected to occupy monitor jobs in the future, a systematic study of prolonged alertness and related monitor problems is of major importance.

At the close of FY 1962, the name of the Task was changed from "Psychological Factors in Consistent Error-Free Performance--ERROR-FREE PERFORMANCE," to "Dependable Performance in Monitor Jobs--MONITOR PERFORMANCE." The change in name parallels a sharper definition of research problems and more closely reflects the research accomplished and projected. The primary objective of the Task as now conceived is to improve performance in U. S. Army monitor jobs, with special emphasis on developing and testing new work methods for use in operational man-machine systems. Psychological problem areas include vigilance and information processing.

The Task has been divided into three subtasks. The first subtask, a study of vigilance under field conditions conducted in cooperation with the American Association of State Highway Officials (AASHO), was completed during FY 1962. The second subtask, "Experimental Laboratory Studies of Vigilance Behavior," is still primarily in the planning stage awaiting the funding and assembly of a vigilance laboratory. Most of the groundwork has been completed. The third subtask, "Human Factors Studies of Critical Jobs in the Operational Setting," was developed to study operational human factors problems of the Army Security Agency. Most of FY 1962 effort on the third subtask was spent in developing appropriate research methods; data collection is expected to begin in the first quarter of FY 1963 after a series of pilot studies has been completed.

THE AASHO ROAD TEST--VIGILANCE RESEARCH

The AASHO Road Test administered by the Highway Research Board provided a framework for the study of vigilance under field conditions. The Road Test was designed primarily to assess the durability of several types and designs of highway surfaces under repeated load applications. The U. S. Army Personnel Research Office conducted the human factors portion of the study with the cooperation of sponsoring organizations. A complement of truck drivers furnished by the U. S. Army Transportation Corps drove large, heavily loaded trucks repeatedly around experimental highway loops during long driving shifts. The Road Test thus represented a natural laboratory for a study of vigilance under conditions of extreme monotony, fatigue, vibration and noise. To take advantage of the unique research setting, USAPRO personnel developed a test that would measure response to signals without interfering with driving safety. The vigilance measure involved the flashing of irregular visual signals from a display unit mounted in the cab of the truck (Figure 1). Drivers were required to respond to signals appearing in designated panels of the display and not to respond to signals appearing in other panels. The percentage of signals detected provided a continuing index of vigilance during the driving shifts. Responses to signals were automatically recorded.

Sustained Vigilance Performance

Primary interest in this phase of the analysis was in finding whether there was a noticeable decline in alertness as a function of time spent driving. The sample consisted of 42 drivers--23 night-shift drivers and 19 day-shift drivers--who had been tested continuously for one full driving shift. Major results were as follows:

1. There was no systematic decline for the group as a whole in the detection of critical signals from one driving period to another (Figure 2). For the day shift drivers, average detection performance across the driving periods was essentially a straight line. (An uncontrolled experimental artifact contaminated night shift scores, causing a spurious increase in detection level.) However, performance declines equal to one or more standard score deviations for the total group were found for 17 percent of the driver sample.

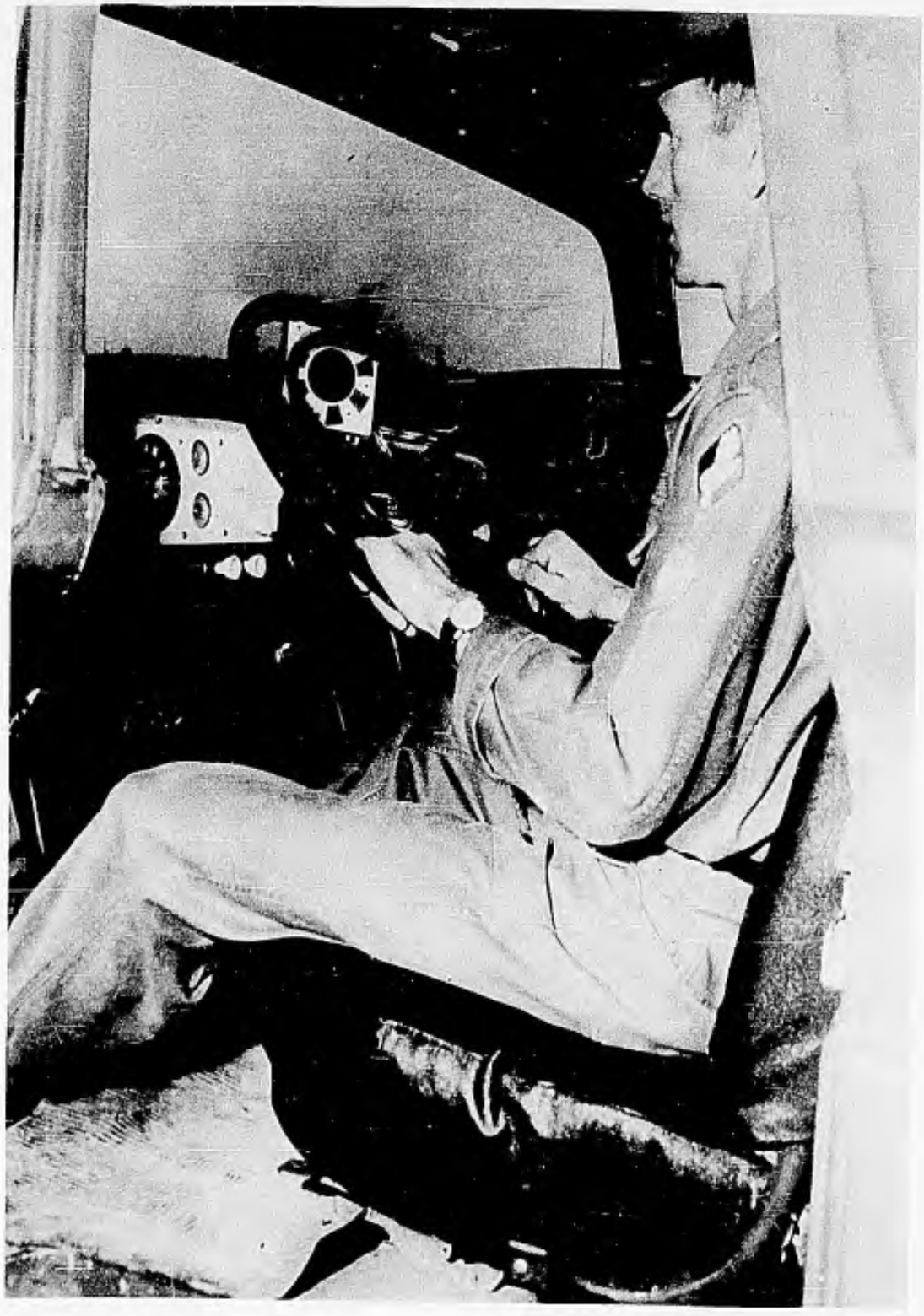


Figure 1. Mounted signal display unit of the Transportation Corps Vigilance Tester

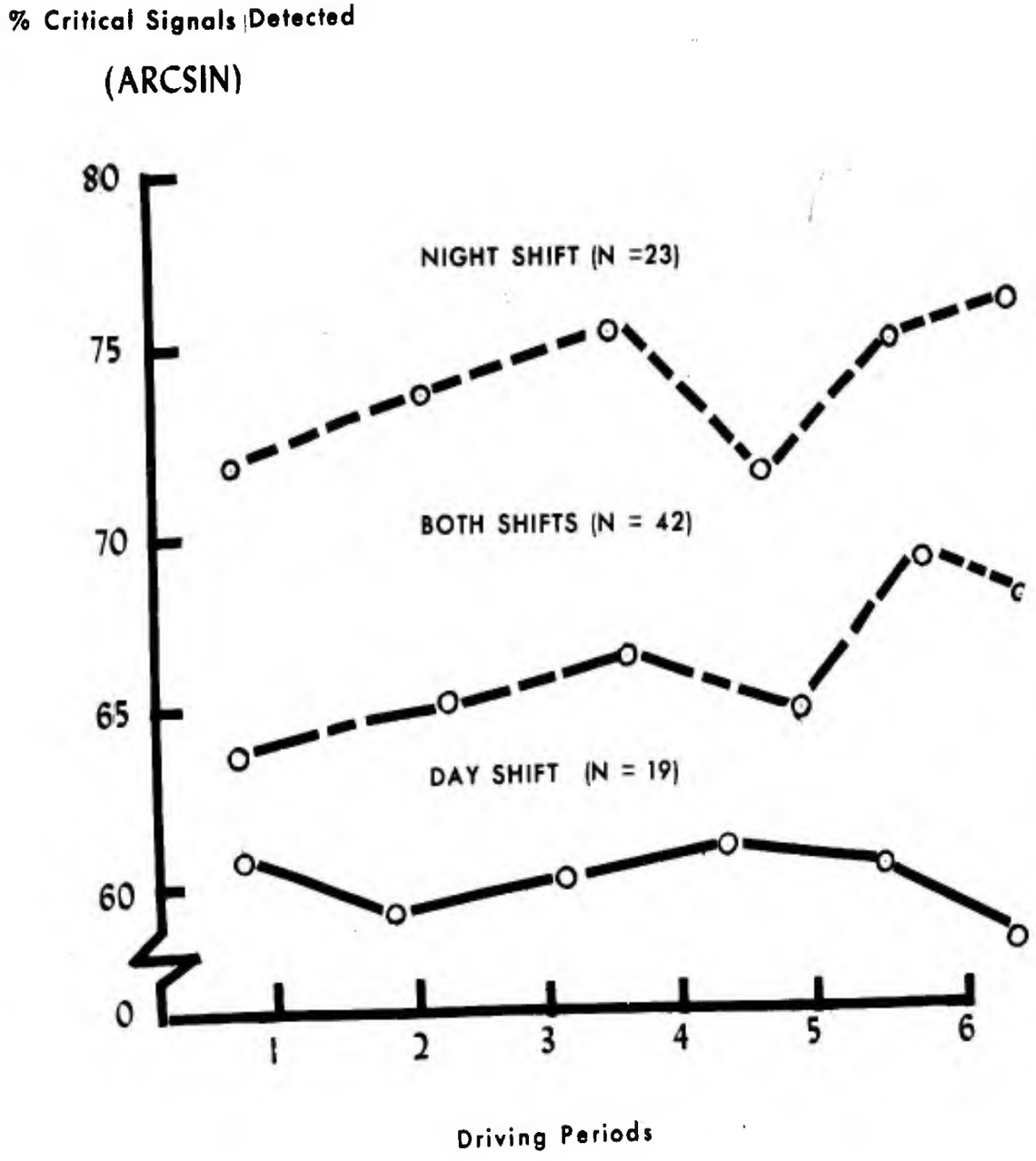


Figure 2. Mean percent detection scores by driving period

2. Overall detection level was surprisingly high: drivers on the average detected 83 percent of all critical signals. Also, the percentage of false detections (signals misinterpreted as critical) was very low--the average was only 4 percent for all drivers for all driving periods.

3. Wide individual differences in the detection of critical signals were found (Figure 3). Percentage detection scores ranged from 21 percent to 100 percent during the last period of driving. Inter-subject variability of detection scores increased significantly from driving period one to driving period six. The effect of the continuous monitoring-driving schedule was thus evident in a "fan-out" of individual vigilance performance rather than in a group decrement.

4. In spite of the fan-out effect, there was a moderately strong tendency for individuals to retain their relative rank order of initial detection performance even after five and one-half hours of interpolated monitoring-driving. Score reliability within a single driving shift was high: augmented odd-even reliability coefficients ranged from .87 to .94.

The major conclusion from the above findings was that, in spite of inhibitory factors (noise, truck vibration, boredom, fatigue) which had led experimenters to expect a decrement in performance, compensatory factors apparently combined to cause the average prolonged high detection levels. The experimental task itself may have been reactive. That is, the very fact that drivers' vigilance performance was being measured may have altered that performance. Also, some evidence from other sources indicates that a fairly complex task such as monitoring-driving affords a variety of sensory and motor stimulation which may enhance detection performance.

Prediction of Individual Vigilance Performance

The second phase of the AASHO study was concerned with prediction of individual differences in vigilance performance through standardized psychological tests and measures. The sample consisted of 111 drivers who has been exposed to a minimum of one and one-fourth hours of vigilance testing. A wide variety of tests was administered to drivers before they began the road test. Represented in the predictor measures were eight generally accepted behavioral domains: physical, psychomotor, perceptual speed, cognitive, driver aptitude, personal history, personality, and attitudinal.

Presently available predictors appear to be of marginal usefulness. Only 12 of 156 obtained validity coefficients (39 predictors x 2 samples x 2 performance measures) were significant at or beyond the 5 percent level of confidence. This finding suggests that future efforts at prediction should be in the direction of developing highly specific predictors closely approximating the characteristics of the specific vigilance job of major interest.

Figure 3. Vigilance performance of individual drivers

Correlation coefficients between the two vigilance measures--percent detection of critical signals and percent false detections--were low and not statistically significant. This finding, if it proves to be a general fact about human monitors, has significance for the selection of individuals for vigilance jobs. In essence, it means that even the alert monitor may make many false detections. In the Army context, the vigilant false detector may be even more dangerous than the non-vigilant monitor, depending on the consequences of his actions.

Scores derived from different driving shifts (separated by four days, on the average) correlated from .42 to .61. This range is not as high as reliability within a single driving shift. A systematic test-retest reliability study of detection performance as a mental function is needed as a basis for deciding how much effort should go into developing conventional selection instruments.

Conclusions To The AASHO Study

The AASHO Road Test was a one-shot research effort by which USAPRO hoped to learn something about how people behave in "real" situations requiring vigilance. Results led to the following conclusions:

1. Jobs which require some activity on the part of monitors do not result in the rather steep decrements in group performance found for passive monitors, even when long vigils are required.

2. However, some monitors (17 percent of the AASHO drivers) show a decline in signal detection performance. The problem of identifying those who are likely to show a decline remains.

3. Most of the variance associated with vigilance performance is attributable to individual differences which seem stable, at least within monitor periods, but not predictable within the range of psychological measures administered in the AASHO study.

SURVEY OF U. S. ARMY MONITOR JOBS

Initial planning of a long-range USAPRO research effort in the area of vigilance required a review of the extensive body of relevant experimental research followed by a survey of Army jobs possessing a vigilance component. The survey undertook to obtain a fund of information on three aspects of Army monitor jobs: number, types, and distributions of duty positions; major characteristics of Army monitor jobs; and the relative importance of monitor jobs in achieving unit missions.

Service elements were requested to examine lists of duty positions (4-digit MOS) under their cognizance, as defined in AR 611-201, and to select those positions requiring vigilance. For each duty position designated as having a vigilance requirement, respondents were asked to complete a questionnaire form. Major results based on the returns are summarized as follows:

1. From a total of 1528 duty positions examined, 102 were designated as having a vigilance component. (Over two-thirds of the questionnaires returned on the 102 jobs indicated that monitor duties took up 50 percent or more of the operator's time.) Seventy-two of the 102 positions were under cognizance of the combat arms and 30 were under the technical services. Within the combat arms, monitor positions were fairly evenly distributed among Armor, Infantry, Air Defense, and Field Artillery. Within the technical services, only the Engineers, Transportation Corps, and the Quartermaster General have substantial numbers of monitor jobs (Figures 4 to 7, inclusive).

2. The monitoring of various types of instrument panel and other equipment accounted for 64 of the 102 positions. Critical signals which monitors were required to detect include specific readings of meters, dials, gauges, scopes, and warning lights. Visual monitoring was more common than auditory. Signals in most monitor jobs were paced by the apparatus or by the environment rather than by the monitor himself.

3. Work periods were found to be widely variable, ranging from ten minutes to four hours, and were largely unscheduled.

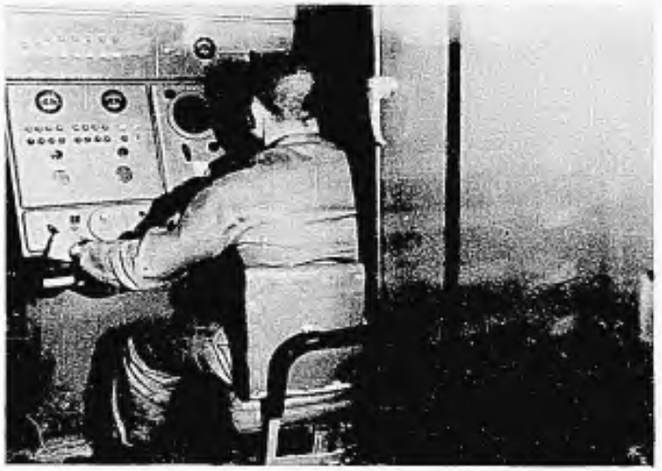
4. Administrative procedures used to check the accuracy of monitor performance varied widely and included reliance on supervision, multiple monitors, and highly standardized operational procedures.

5. Human factors problems reported as encountered in monitor jobs included operator fatigue, extraneous noise, physically cramped work areas, weather extremes, and emotional stress. Essentially the same problems--greatly intensified--were anticipated for monitor jobs if performed under combat conditions.

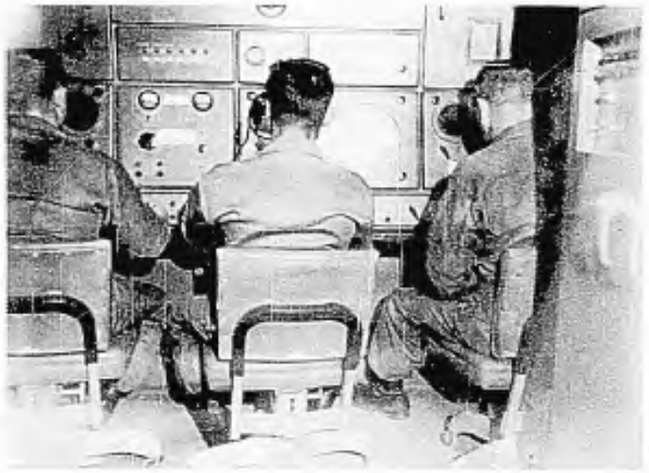
6. In general, the monitor jobs surveyed were reported as important to the achievement of unit missions. Eighty-four percent of all monitor jobs surveyed were rated as either "extremely" or "critically" important. Possible consequences of poor performance in monitor jobs were cited: delays in launching missiles, losses of equipment, delays in or disruption of communications intelligence, destruction or retreat of tactical units, delays in detecting aggressor missiles or aircraft, inaccurate placement of artillery fire, destruction of U. S. Army heavy weapons.

The substantial number of jobs requiring vigilance, and the wide distribution of these jobs across many service elements of the Army, confirmed the utility of a broad program of vigilance research. Survey findings helped to determine the focus of ensuing research. For example, monitoring jobs requiring observation of multiple-signal-source instrument panels--a type of monitoring seldom investigated in past research efforts--were most frequently reported in the survey. Based on this evidence, the multiple-signal console or instrument panel will be the focal point of future USAPRO research. Many characteristics of monitor jobs and associated problems mentioned in the questionnaire returns--administrative practices, work-rest cycles, fatigue and stress states, to name a few--lend themselves to a human factors research approach and have been incorporated in USAPRO research planning.

Field Artillery Mortar-location Radar Operator



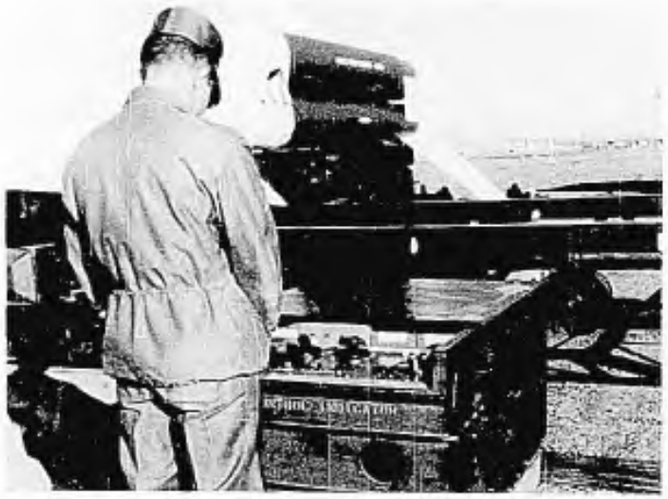
Air Defense FC Radar Operator (Nike-Hercules)



Air Defense Target Tracker Radar Operator (Nike-Ajax)

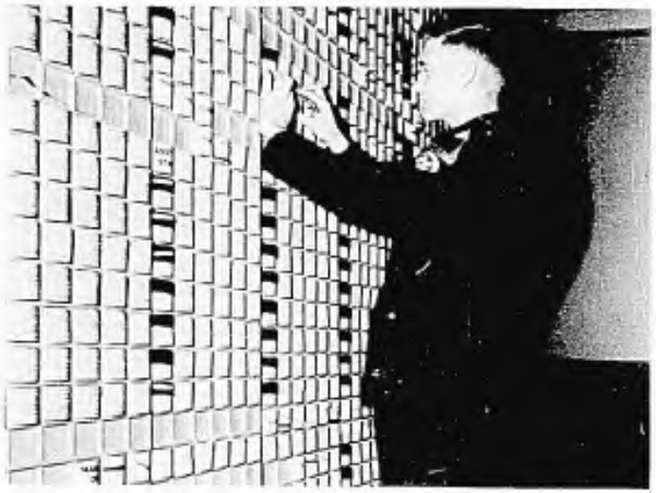
Field Artillery Forward Observation Radar Operator

Figure 4. Examples of U. S. Army monitoring jobs: Combat arms--radar

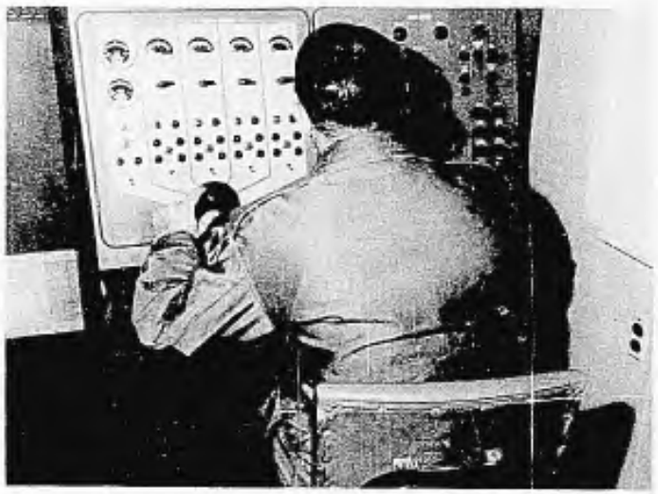


Air Defense Fire Control Crewman (Nike)

Field Artillery Sound Ranging Crewman



Armor Operations Specialist



Air Defense Launching Control Console Operator

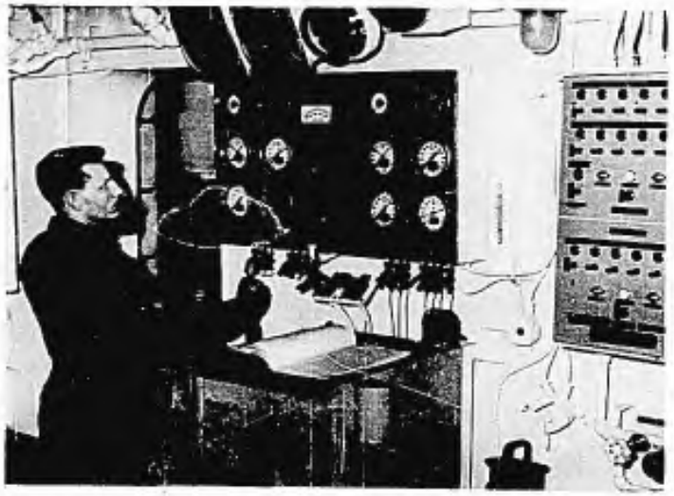
Figure 5. Examples of U. S. Army monitoring jobs: Combat arms--equipment

Infantry Forward Observer

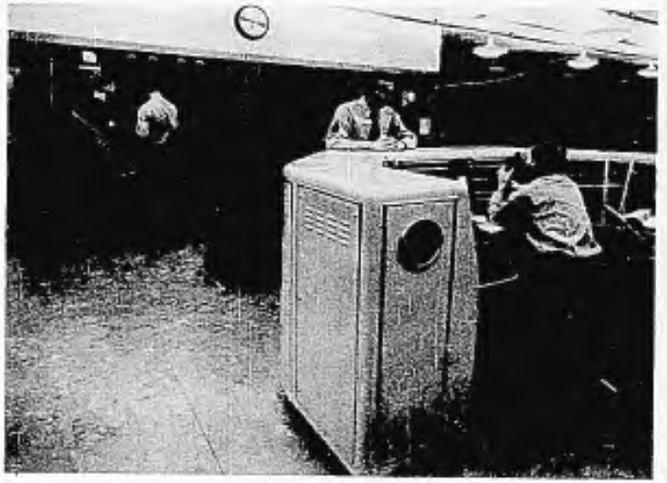
Artillery Sound Ranging Crewman

Infantry Fire Direction Computer

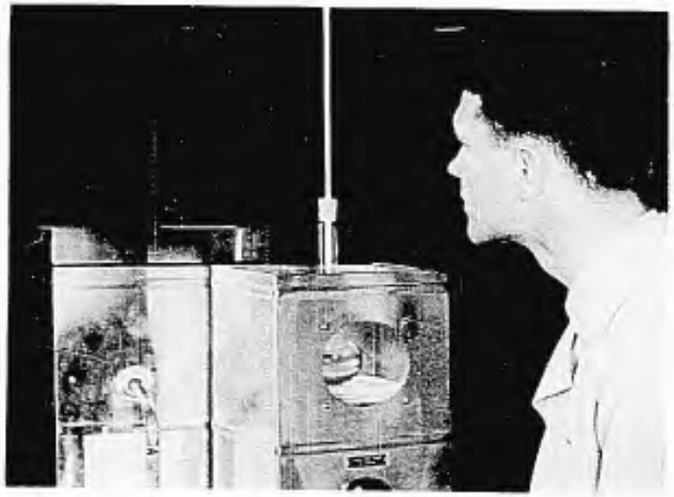
Figure 6. Examples of U. S. Army monitoring jobs: Combat arms--terrain



Transportation Corps Marine Engineer



Signal Corps Communication Receiver



Quartermaster General Laboratory
Specialist

Corps of Engineers Nuclear Power
Specialist

Figure 7. Examples of U. S. Army monitoring jobs: Technical services--equipment monitors

EXPERIMENTAL LABORATORY STUDIES OF VIGILANCE BEHAVIOR

The AASHO study could not be designed to permit experimenters to isolate and measure the independent variables influencing performance. A more systematic approach was initiated in FY 1961 to investigate factors associated with the signal monitored, the task, the environment, and the individual, each with respect to monitor performance. Factors selected for study have been restricted to those with application to Army monitor jobs and, further, with application to problems for which no satisfactory resolution may be found in the scientific literature. The review of factual information established in prior research served to identify areas of vigilance behavior in which present information is either inconclusive or nonexistent.

Some twenty variables of varying generality have been identified which form the basis for the long-term research program planned by USAPRO. These variables are subsumed in the following five categories.

Signal Characteristics

Signals emanating from the monitored display show variation in rate, magnitude, and intersignal interval. This class of variable has been more thoroughly investigated than have the four remaining categories, and a considerable body of useful research information exists. One example of research that is contemplated in this area: Artificial signals deliberately programmed into the monitor task have been shown to enhance detection of the critical signals. There is much room for enlargement of this research area through studies to establish the types of artificial signal that prove most effective in improving detection, the nature of monitor adaptation to the artificial signals, and the influence of artificial signals on false as well as on true detection.

Immediate Task Factors

A number of factors are present in the monitor situation, factors not directly associated with the observing process--administrative practices, work-flow, work-rest scheduling, and the immediate physical environment of the monitor. Research dealing with this class of variables can have immediate operational impact, because results can be implemented by administrative decision without corresponding change in hardware or personnel standards. Researchable areas in this category include the evaluation of work methods and the amount and nature of supervision required to keep detection accuracy at high level.

General Environmental Factors

This class of variables refers to aspects of the environment associated with geography, climate, and the broad physical surround of the monitor. Research on these factors is best done in a field setting

because of simulation difficulties. However, one problem frequently mentioned by questionnaire respondents in the job survey lends itself to laboratory investigation: The high level of the ambient noise generated by auxiliary equipment is troublesome to monitors in some operational settings. The noise could easily be simulated--and controlled--by recording equipment for laboratory study.

Personal Factors--Variable

Variable internal states of the individual monitor may influence his overt performance. Fatigue was prominently mentioned in the job survey as a source of concern, particularly in the combat situation. Questionnaire respondents were referring to physical fatigue caused by required manual labor and long working hours prior to beginning the monitor task. Physical fatigue is thus differentiated from "operator fatigue," a term often applied to vigilance decrement. In the mobile Army envisioned for the future, operators would be required to help in the physical activity occasioned by frequent changes in the location of equipment. There is no conclusive research evidence as to the effect of this important variable on monitor performance.

Personal Factors--Individual Differences

This category refers to pre-existing, more or less permanent, individual traits which monitors bring with them into the job situation. Wide individual differences in performance have invariably been found in vigilance experiments, including the AASHO studies. But attempts to achieve prediction of monitor performance through individual differences as measured by standardized psychological tests have so far been unsuccessful. In the AASHO study, the disappointingly low relationship between predictor tests and vigilance performance could be attributed in part to instability of the particular criterion measure used. Research is needed to determine (1) the test-retest reliability of monitor performance over varying lengths of time, and (2) the extent to which performance in one type of monitoring generalizes to other types. Upon the degree of stability characteristic of vigilance criteria depends the amount of research effort that should be devoted to developing predictors for use in monitor selection and utilization. Several measures are under consideration for development as predictors if the nature of the criterion is found to warrant the effort. Among the prospective measures are examiner-paced perceptual tests, specially constructed personality inventories, and measures of time perception.

DEVELOPMENT OF A VIGILANCE LABORATORY

Realization of the projected research program in vigilance depends upon the funding and assembly of a laboratory simulator. Concurrently with the research projects now in progress, Task personnel designed a versatile laboratory simulator by which the relevant features of many

important monitoring jobs may be studied. The following performance characteristics of the simulator have been specified as requisite to the study of a broad range of monitor problems:

1. The apparatus should have interchangeable instrument panels so that different instrument configurations may be reproduced.

2. Experimenters should have full control and wide choice of relevant signal parameters, such as signal rate, intensity, duration, and intersignal interval.

3. The apparatus should allow signals to appear simultaneously or consecutively from all signal sources.

4. The apparatus should generate both auditory and visual signals.

5. The number of available signal sources should be high to allow for studies of complex as well as simple vigilance behavior.

6. The apparatus should be reliable and easily maintained.

7. The apparatus should allow for testing as many as five subjects during any one session.

8. Data recording should be automatic or near-automatic.

Research scientists were helped in planning the simulator by observation of simulators used by the Lockheed Aircraft Company, the U. S. Army Surgeon General, the National Institute of Health, the Human Resources Research Office, the Human Engineering Laboratories, the Naval Training Devices Center, and the Otis Elevator Company.

Early in FY 62, an instrumentation expert was hired to translate performance characteristics into engineering drawings, wiring diagrams, and parts lists. Completed plans are considered to represent a good balance between the realities of the operational setting and the need for experimental controls. Monitor tasks are represented on the instrument panels by the same kind of meters, lights, and gauges as on operational consoles. These realistic displays are considered an improvement over simulated displays in that they are more likely to result in applicable principles of behavior.

An overall view of the proposed laboratory is shown in Figure 8. The apparatus consists of two major components, the control center and the monitor console (Figures 9 and 10).

The control center will consist of three systems. In the program coding system, signal commands are programmed on magnetic tape. The coding system will consists of ten pure tones of different frequencies imposed on each of eight tape channels. Each tone will represent a different command governing a particular signal characteristic such as intensity, rate, and location. The decoding and demand system will

activate appropriate signals on the operator console. Here, the completed program will be played back. Coded commands will activate specific signal devices on the signal panels of the monitor consoles. In the data accumulation and tabulation system, both signal and response data will be accumulated automatically and printed out at specified intervals.

On the monitor console as many as 59 different signal can be presented simultaneously or separately. Auditory and visual signals can be presented independently or redundantly. Multiple response outlets will permit experimenters to interchange various response media so as to produce any desired combination of levers, pushbuttons, knobs, pedals, toggle switches, and control wheels.

Plans call for construction of the vigilance laboratory during FY 1963. To summarize plans for use of the laboratory facilities, first emphasis will be placed upon investigation of factors associated with immediate vigilance tasks. These are factors which can be implemented in operational systems without drastic changes in hardware or personnel standards. Criterion measures to be developed through use of the simulator are basic to the validation of personnel selection techniques for better identification of personnel who will perform dependably through the long and often monotonous vigils associated with monitor jobs.

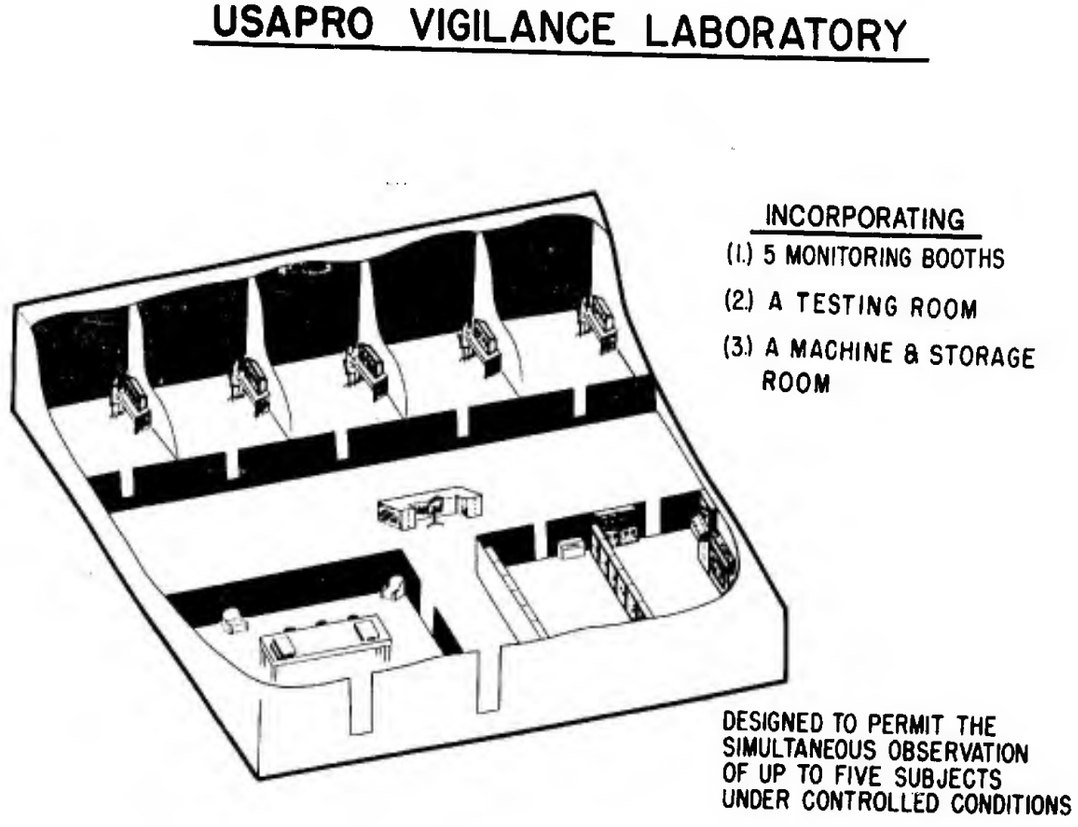
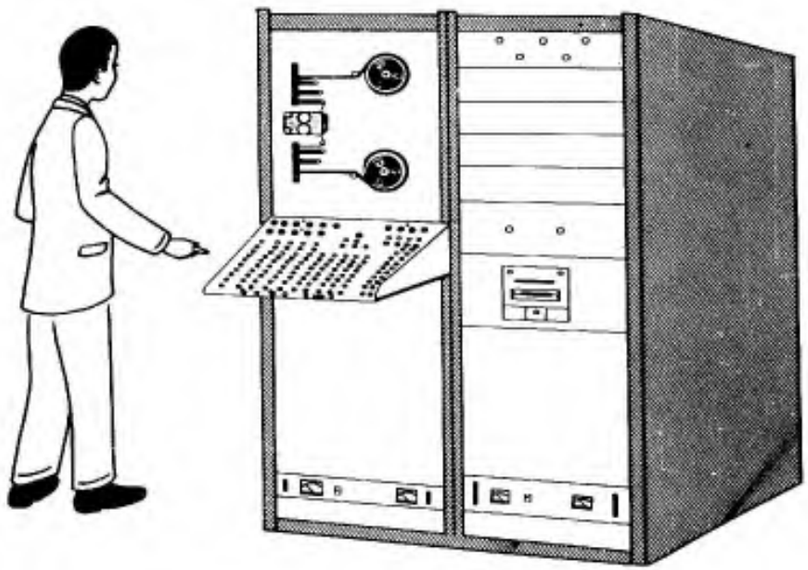


Figure 8. Proposed USAPRO vigilance laboratory

CONTROL CENTER



INCORPORATING

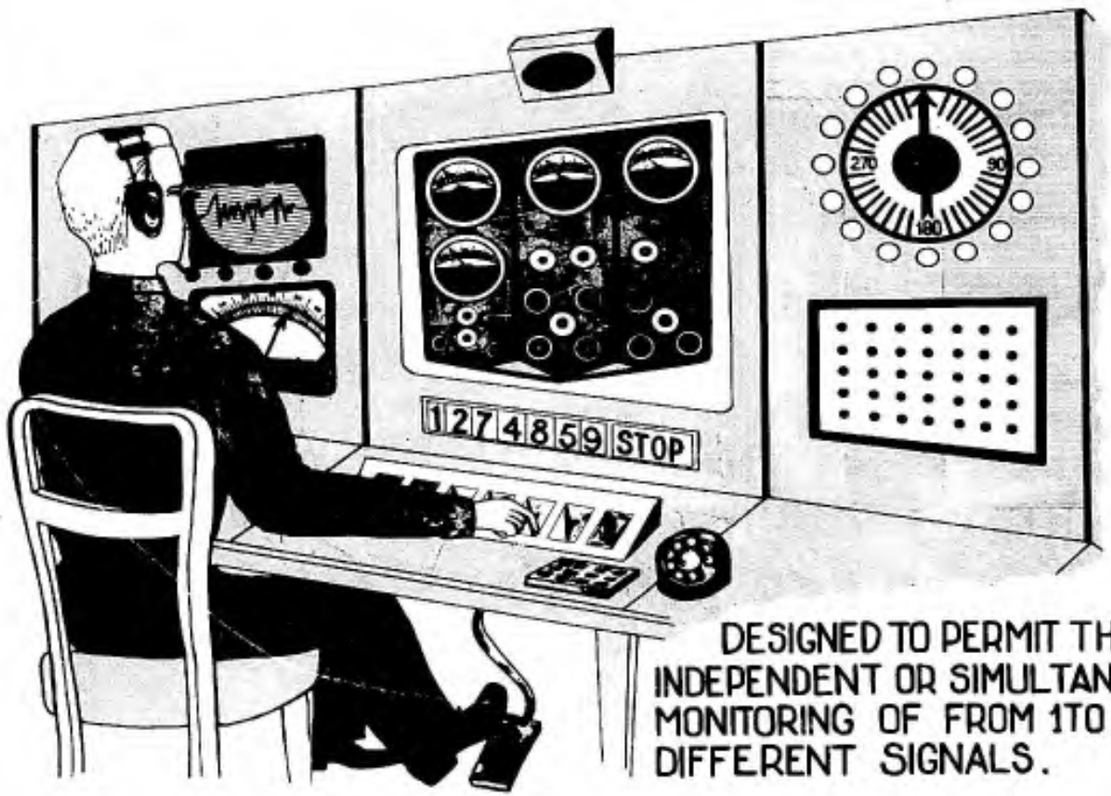
1. TASK PROGRAMMING
2. PROGRAM PRESENTATION
3. DATA ACCUMULATION
4. DATA RECORDING

DESIGNED WITH EMPHASIS ON MAXIMUM VERSATILITY AND CONTROL OF SIGNAL CONDITION VARIABLES* ASSOCIATED WITH ARMY MONITORING TASKS. AUTOMATIC DATA RECORDING PROVIDES A CONTINUOUS RECORD OF EACH SUBJECT'S MONITORING BEHAVIOR.

*SIGNAL RATE, INTENSITY, & DURATION

Figure 9. Control center

USAPRO VIGILOMETER



DESIGNED TO PERMIT THE INDEPENDENT OR SIMULTANEOUS MONITORING OF FROM 1 TO 59 DIFFERENT SIGNALS.

INCORPORATING
(SIMULATED)

COLORED INDICATOR LIGHTS
SEQUENCE LIGHTS
PATTERN LIGHTS
METERS
DIALS
ALPHANUMERIC INDICATORS
DIRECTION FINDER
OSCILLOSCOPE
SURVEILLANCE TELEVISION
RADARSCOPE
SONAR SIGNALS
TONE SIGNALS
BACKGROUND NOISE

HUMAN FACTORS STUDIES OF CRITICAL JOBS IN THE OPERATIONAL SETTING

The third subtask was planned to be responsive to the Army Security Agency, which generated requirements for human factors research in several important areas of security operations. The content of specific projects is classified, and cannot be fully discussed. However, the projects specified for research include problems of signal monitoring and information processing.

Beginning in FY 1961, following trips by task personnel to the U. S. Army Security Agency Training Center at Fort Devens, Massachusetts, a survey of human factors problems was made. USAPRO personnel submitted a series of research proposals, based in large part on interviews with subject-matter specialists, to the Army Security Agency Board in June 1961. Two specific research projects were selected for initiation in November 1961. Following consultation with subject-matter personnel representing different aspects of the requirement, detailed research plans were developed. The problem materials, necessary equipment, and personnel to serve as experimental subjects were designated during the last quarter of FY 1962.

The characteristic research design for studies under this subtask involves the simultaneous investigation of two types of independent variable. The first type represents variables known or hypothesized to influence human performance, and the second type represents various work methods hypothesized to be differentially effective in optimizing performance. The work-method class of variable characterizes a methodology sometimes described as "job engineering," in which flow, sequence, or method of work is systematically rearranged among job incumbents until a more accurate or timely end-product results.

Research with the Army Security Agency is expected to continue for several years. As research progresses, coordination will be effected with counterpart elements in other Department of Defense activities.

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